5.2.2. AUTOMATED FOUR-CHANNEL FIELD GAS CHROMATOGRAPHS

The NOAH Division continued to build and test the newest generation of four-channel GCs. These instruments are designed to make frequent, automated measurements of radiatively important and halogenated trace gases. The deployment of four-channel GCs at existing CMDL observatories (BRW, MLO, SMO, and SPO), the NWR cooperative site, and new field sites at WITN tower (North Carolina), Harvard Forest (Massachusetts), and Alert, Canada, will expand both the geographical coverage of trace gas monitoring and the number of species measured.

Features

Much of the technology found in the new generation of field GCs has evolved through the development of compact, lightweight, automated GCs for in situ trace gas analysis aboard the ER-2 aircraft. Thus, the field GCs are very compact and modular with each channel having its own 12-port gas sampling valve, chromatographic column pair, ECD, and electrometer. If a component requires maintenance or repair, it can effectively be removed and replaced without disrupting measurements on the other channels.

The control and acquisition software for the instrument runs on a conventional IBM-compatible personal computer with a 80486 CPU. The control and data acquisition hardware within the GC consists of a 96-channel analog-to-digital (A/D) board, a digital I/O board, and a dedicated four-channel A/D board for logging ECD signal data. The run program includes on-screen display of chromatograms and pertinent engineering data such as component and zone temperatures, sample loop flow rate and pressure, carrier gas flow rates, carrier gas and calibration gas tank pressures, and the relative humidity of the sample stream. A new and extremely useful feature of the run program is the real-time integration of peaks, which permits a "quick look" at data and aids in troubleshooting.

Using an eight-port stream selection valve, several ambient air streams and calibration gas flows can be sampled and analyzed in a user-defined sequence. Ambient air streams are dried through Nafion tubing to a dewpoint of -25°C before analysis. The four sample loops are pressure-controlled using a pressure sensor and valve feedback system.

Each column pair, ECD, mass flow controller and sample loop is isothermally maintained by proportional, integral, derivative algorithm temperature controllers. Temperature data are logged to disk by an RS-485 loop between the temperature controllers and the computer, and controller setpoints can be changed from the keyboard. Column pairs and ECDs are encapsulated in well-insulated, cylindrical ovens 13 cm in diameter and 18 cm high that provide excellent temperature stability (1 s.d., ± 0.1°C).

There are currently five possible channels for implementation in these four-channel automated gas chromatographs. The more pertinent chromatography parameters for each channel are listed in Table 5.3. These include column dimensions (o.d. × length) and packing materials, sample loop sizes, special detection methods employed (if any), species measured, and the precision of measurement of each specie at its mixing ratio in high-pressure tanks of Niwot Ridge air.

Work will begin in 1994 to utilize the sample loop pressure control for "pressure-calibrations," the injection of different pressures of a calibration gas to generate calibration curves. Pressure-calibration curves show little nonlinearity over a pressure range of 15% (90% to 105% of a given setpoint). If satisfactory results can be obtained through this method, the need for having several calibration tanks at a given site will be eliminated.

TABLE 5.3. Pertinent Chromatography Parameters for Each Channel of New Automated Field GC, Species Measured, and Precision of Measurements

Parameter	Description
	Channel 1
Precolumn	3.175 mm × 2.0 m unibeads 1S
Main column	3.175 mm × 4.0 m molecular sieve 5A
Sample size	5 cm^3
Detector	N_2O-doped ECD
Species measured:	*Precision:*
H_2	0.6%
CH_4	0.4%
CO	1.0%
	Channel 2
Precolumn	3.175 mm × 1.5 m unibeads 2S
Main column	3.175 mm × 2.5 m unibeads 2S
Sample size	2.5 cm^3
Detector	ECD
Species measured:	*Precision:*
CFC-12	0.2%
CFC-11	0.2%
CFC-113	2.8%
	Channel 3
Precolumn	3.175 mm × 2.0 m OV-101 (20%)
Main Column	3.175 mm × 5.0 m OV-101 (20%)
Sample size	5.0 cm^3
Detector	ECD
Species measured:	*Precision:*
CFC-11	0.2%
CFC-113	0.5%
Chloroform	5%
Methyl chloroform	0.5%
Carbon tetrachloride	0.5%
Trichloroethylene	Unknown
Perchloroethylene	1.5%
	Channel 4
Precolumn	4.7625 mm × 2.0 m Porapak Q
Main Column	4.7625 mm × 3.0 m Porapak Q
Sample size	15.0 cm^3
Detector	ECD
Species measured:	*Precision:*
N_2O	0.2%
SF_6	1.2%
	*Channel 5**
Trap no. 1	3.175 mm × 0.040 m unibeads 1S
Trap no. 2	3.175 mm × 0.024 m Porapak Q
Precolumn	3.175 mm × 0.5 m unibeads 2S
Main column	3.175 mm × 1.0 m unibeads 2S
Sample size	40.0 cm^3
Detector	O_2-doped ECD
Species measured:	*Precision:*
HCFC-22	2.8%

*Samples are first pre-concentrated on trap no. 1 cooled to -50°C. Species of interest are desorbed from this trap by heating to 110°C, then are focused on trap no. 2 cooled to -50°C. Trap no. 2 is rapidly heated to 110°C just prior to injection.